PI Assurance and Funding Information

ACUP ID (IACUC Office assigned number): 4884

1. Principal Investigator (PI): Bruce Mate
(Students may not serve as PIs)

2. Department: CAS/Marine Mammal Institute

3. **Assurance: I accept and assure compliance with all federal, state and institutional regulations concerning the care and use of animals. I will notify the Institutional Animal Care and Use Committee of any changes in the proposed project or personnel prior to initiating or continuing any animal use and will report any adverse events. I certify that all laboratory personnel handling animals will be adequately trained for all animal protocols used in the project and will be enrolled in the Institutional Occupational Health Program for Personnel with Animal Contact. I attest that the information contained in this ACUP submission is complete and accurate to the best of my knowledge.**

_____

Principal Investigator signature **Date**

4. Project title or course name and number: Movements and critical habitat studies of endangered large whales.

5. Is this a project continuation from an expired/expiring ACUP? Yes ☒ No ☐
If yes, prior ACUP # 4495

6. Funding source(s) list all that apply, including departmental. Include associated titles:
Office of Naval Research (ONR), National Oceanic and Atmospheric Administration (NOAA), HDR, Inc., OSU Marine Mammal Institute Endowment Program

Provide a copy of the grant proposal or class syllabus. An electronic version is preferred.

JUSTIFICATION FOR USE OF LIVE VERTEBRATES

7. In lay terms, explain the objectives or goals and benefits or significance of the proposed research, testing, or instructional use of animals. This section should be drafted so a non-scientist would understand it. If technical terms or scientific jargon need to be used, please provide explanations the non-scientist will understand.

Satellite-monitored radio telemetry and data-logging devices will be used to study the movements and dive characteristics of free-ranging cetaceans. The objectives of the proposed research are to: (1) identify migration routes; (2) identify specific feeding and breeding grounds for each species, if unknown; (3) characterize local movements and dive habits in both feeding and breeding grounds, and during migration; (4) examine the relationships between movements/dive habits and prey distribution, time of

day, geographic location, or physical and biological oceanographic conditions; (5) characterize whale vocalizations; and (6) characterize sound pressure levels to which whales are exposed.

Our knowledge of whale movements and distribution is far from complete, particularly outside U.S. waters. For some of the species listed in this application, the location of either their feeding or breeding areas remains unknown, as do their migratory routes. Additional studies using satellite-telemetry and data-logging devices will build upon past research and help us identify unknown habitats and further our understanding of the distribution and 3-dimensional movements of cetaceans in the world's oceans. Such information allows for improved understanding of critical habitat requirements and amount of whales' exposure to anthropogenic activities (shipping, fishing, seismic activity, military activity, renewable energy development and operation). An appreciation of the areas of the ocean that are critical to whales and what oceanographic features are associated with these areas can help in the identification of regions and conditions warranting special protection. For conservation measures to be successful, an accurate knowledge of how a species' range might change with changing oceanographic conditions in the future is also critical. The diving/surfacing behavior information is valuable in assessing whales' reactions to human disturbance, and can also be helpful in the development of more accurate abundance estimations.

8. Provide an explanation for why live vertebrate animals are needed for the proposed project. In addition, please describe the non-animal alternatives that were considered.

This research focuses on identifying and characterizing the habitats, dive habits, and feeding/breeding/migratory movements of free-ranging whales. There are no non-animal alternatives.

9. Explain why each specific species was selected. What biological characteristics make this the best model for the work?

All species listed in this application, with the exception of minke whales, transient and offshore killer whales, Bryde's whales, and the Eastern Pacific stock of gray whales, are endangered and the most in need of careful resource management and conservation. Problems regarding ship strikes, tourism, acoustic harassment (ship or seismic noise), fishing and other forms of human encroachment on whale habitats require additional understanding of whale movements and home range. This is the type of work we specialize in.

While the eastern Pacific stock of gray whales has been taken off the Endangered Species list, their very nearshore migration makes them particularly vulnerable to potentially deleterious anthropogenic activities in the ocean. Minke whales continue to be killed for scientific research and commercial harvests around the world; information concerning stock identity and distribution is critical to proper management of these harvests. Very little is known about the movements and distribution of the different stocks of killer whales or Bryde's whales, especially in the North Pacific. Recent improvements in tag technology have allowed for the development of smaller tags than we've used in the past, enabling us to instrument smaller animals, such as killer whales and minke whales. And though Eastern gray whales, killer whales, Bryde's whales, and minke whales are not endangered, an understanding of the juxtaposition of human use of the oceans and their movements continues to be important.

Animal Species and Use Categories

10. List the species and total number of animals that will be used by category below. The category indicated is determined by the procedures to be performed on the animals. A description of each category, as defined by the USDA's Animal Welfare Act, is provided below.

Animal numbers must include the total number for all three years of the ACUP.

Add additional lines or submit additional pages, as needed.

Common name of species	B	C	D	E
Blue Whale		150		
Bowhead Whale		150		
Bryde's Whale		150		
Fin Whale		150		
Gray Whale (Eastern North Pacific Stock)		150		
Humpback Whale		150		
Minke		150		
Sei Whale		150		
Southern Right Whale		150		
Sperm Whale		150		
Killer Whale (excluding North Pacific Southern Resident Stock)		60		
North Pacific Right Whale		60		
Gray Whale (Western North Pacific Stock)		25		
Grand Total (all 3 years)		1,645		

"B" Breeding Colony or Holding Protocols-No procedures performed, aside from breeding (e.g., no tail biopsy/clips, etc.)

"C" No more than momentary or slight pain or distress and no need for pain-relieving drugs, or no pain or distress.

"D" More than momentary discomfort, distress, or pain in which a veterinarian or human doctor would require relieving this with anesthetics, analgesics and/or tranquilizer drugs or other methods for relieving discomfort, distress, or pain.

"E" More than momentary discomfort, distress, or pain in which a veterinary or human doctor would require relief, however, the use of these agents would interfere with the scientific outcome. Requires completion of Category "E" supplement.

11. Specify the number of animals needed and include any calculations used to determine minimum group or sample size. Also, include the "Animal Use Category" that corresponds to the proposed work and provide an explanation/justification for selection. It is suggested that tables or charts be used so that experimental groups are clear and can be matched to procedures performed. An explanation of the procedures should not be included in this section.

We are requesting authorization to tag and biopsy sample 150 each of blue whales (Balaenoptera musculus), bowhead whales (Balaena mysticetus), Bryde's whales (Balaenoptera edeni), fin whales (Balaenoptera physalus), Eastern North Pacific stock gray whales (Eschrichtius robustus), humpback whales (Megaptera novaeangliae), minke whales (Balaenoptera acutorostrota), southern right whales (Eubalaena australis), sei whales (Balaenoptera borealis), and sperm whales (Physeter macrocephalus), 60 killer whales (Orcinus orca), 60 North Pacific right whales (Eubalaena japonica), and 25 Western North Pacific stock gray whales (Eschrichtius robustus), in U.S., foreign (with appropriate local permits) and international waters over a 3-year period. The requested numbers give us the flexibility to conduct multiple field projects per year, either on different species, or different populations within the same species. The procedures outlined in this ACUP would constitute Animal Use Category "C". Tagged whales may experience pain or distress at the time of tagging, but our veterinary consultant specialists (J. Geraci, W. Medway and S. Brown) believe this to be negligible and short-lived. In the vast majority of our tag deployments on blue and fin whales there is no response to tagging. In the case of other species, some individuals exhibit short-term, startle responses (i.e. quick dive, fluke kick, head lift). Reactions occur in response to tag deployment and sometimes to the close boat approach necessary for such deployments even when tags are not applied. However, usually within minutes of tagging, whales often resume their pre-tagging behavior. There are currently no means of assessing discomfort or pain associated with tag retention for free-ranging cetaceans (Best et al., 2014). In the absence of such data, follow-up observation of tagged whales remains the only way to determine the implications of tagging on individuals. In follow-up observations, tagged whales have not appeared to be in poor health. None of the animals were emaciated or had higher than normal external parasite loads, and they behaved similarly to other untagged whales in the area when resighted. As stated in Question 21 below, both resight rates and reproductive rates have been shown to be similar between tagged and untagged whales.

In previous tagging studies of right whales, bowheads, and blue whales, individuals within the same species have been shown to have different movements and dive habits (Mate and Nieukirk 1992, Mate et al. 1997, Mate et al. 1999, Krutzikowsky and Mate 2000, Lagerquist et al. 2000, Mate et al. 2000). More recently, we have found evidence that males, females, and females with calves show differences in surfacing rates and movements within/between feeding and breeding areas (Lagerquist et al. 2008, Mate et al. 2003, Mate et al. 2010). In addition to sex differences, we wish to explore whether there are differences between juvenile and adult behaviors. This results in five population subgroups (males, females, females with calves, juveniles, and adults). An ideal sample would include all five of these subgroups. Tag "failure" however, must be taken into account with regard to sample size decisions, as achieving 100% success in tag deployment, retention, and function is extremely rare. Tags may be imperfectly deployed due to a number of reasons, including whale movement at the time of deployment, individual whale differences in tissue density at the tagging site, differences in air pressure in the deployment equipment, or malfunctions of the deployment equipment. Hydrodynamic drag is a constant force trying to pull the tag from the whale's body, and tag retention is a function of how fully a tag is deployed, the angle of deployment, and tag location on the whale's body. Individual variation in tissue response and how this contributes to tag retention as well as the migration of foreign material out of tissue also plays a role in how long a tag remains attached to a whale. Tags may not function properly if they are damaged upon deployment or from contact with other whales, as may be the case with mothers/calf pairs or whales engaged in breeding activities. Such whale to whale contact may also affect tag retention. Because only 60% of our ARTS-applied Argos satellite tags transmit for 2 months or more, a minimum of 5 animals per subgroup (3 + 2 potential "failures") is necessary to ensure a successful time series of data permitting statistical comparisons between subgroups. For analysis of longer-term trends, only 30-50% of tags last longer than six months requiring 6+ animals per subgroup. This results in a minimum projected total of 25 per experiment, which is also realistically near the maximum that can be financially and logistically realized. Though it is unlikely we will have all 5 subgroups represented (much less equally represented) in a sample, 25 per experiment allows for larger than minimum sample sizes in fewer subgroups. Further complicating the issue of sample size is the fact that our biopsy sampling success rate is typically 70% or less, due to practical limitations (whale's submerging right after tagging and preventing the collection of a biopsy sample), thereby reducing the number of animals of known sex even further.

As individual variability in many behaviors is quite high, the minimize sample size may not provide sufficient power to distinguish differences between groups. For example, in an attempt to detect differences in the speeds between male and female sperms whales, a sample size of 18 (10 females, 5 males, 3 unsexed), had insufficient power to detect a 10% difference in speeds (90% power; 95% confidence level). However, we were able to distinguish surfacing rate differences between southern right whale cows with calves (n = 4) and other adults (n = 11). As our database continues to grow and we gain an understanding of the sources of variability (i.e. year, season, age/sex class, environmental factors, etc.) we should be able to perform analyses across years to test hypotheses with sufficient power at a later date. A recent paper (Bailey et al. 2010) combining our data from 14 experiments of blue whales over a 15-year time span (total 128 successful tags) detected significant speed of travel differences between migratory and area restricted search behavior.

In the case of developing tags with new technology and more sophisticated behavioral sensors (e.g. Fastloc GPS/TDR/acoustic tags and lunge-detecting tags), the success rate of attachment, transmission, retrieval of data, and individual variability in behavior is not well enough established to determine needed sample sizes. To date, the recovery rate for our archival GPS/TDR tag deployments has been highly variable between studies/years, as the technology continues to evolve and improve, ranging from 75-100% for blue whales, 33-50% for fin whales, and 9-56% for sperm whales. The recovered data show individual variability in diving behavior, and some suggestion of differences between male and female blue whales, but sample sizes are small, not only because of recovery rates, but also because of financial reasons (the cost of archival GPS/TDR tags is more than three times the cost of our non-recoverable Argos tags). Thus we will attempt to deploy the maximum number of these tags as funding sources allow, to account for temporal, spatial, and individual variation in diving behavior. It is unlikely this number would ever exceed 25 tags per field season.

We have requested to tag 150 individuals of most species over a three-year period, as this will allow for multiple field seasons (i.e. different locations) for a particular species in a given year. Our request for at least two possible experiments of each species in a year gives us the option to add to our knowledge about animals in different geographical/seasonal areas, different stocks, and/or under different environmental conditions. The possibility of multiple studies per species occurring in all three years is extremely low. However, we have based our total number of requested animal takes (150 for most species) on just that possibility to ensure we are covered should such opportunities arise (especially for international collaborations).

Literature Cited

Bailey, H., B. R. Mate, D. M. Palacios, L. Irvine, S. J. Bograd, and D. P. Costa. 2010. Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. Endangered Species Research 10:93-106.

Best P.B., B. Mate, and B.A. Lagerquist. 2014. Tag retention, wound healing, and subsequent reproductive history of southern right whales following satellite-tagging. Marine Mammal Science. 31(2):520-539.

Krutzikowsky, G. K. and B. R. Mate. 2000. Dive and surfacing characteristics of bowhead whales (Balaena mysticetus) in the Beaufort and Chukchi Seas. Canadian Journal of Zoology 78:1182-1198.

Lagerquist, B. A., K. M. Stafford, and B. R. Mate. 2000. Dive characteristics of satellite-monitored blue whales (Balaenoptera musculus) off the central California coast. Marine Mammal Science 16(2):375–391.

Lagerquist, B., B. R. Mate, J. G. Ortega-Ortiz, and M. Winsor. 2008. Migratory movements and surfacing rates of humpback whales (Megaptera novaeangliae) satellite tagged at Socorro Island, Mexico. Marine Mammal Science 24:815-830.

Mate, B.R. and S.L. Nieukirk. 1992. Satellite-monitored movements and dive behavior of the right whale, Eubalena glacialis, in the western North Atlantic. Minerals Management Service Final Supplemental Report, Dec. 1992. Contract No. 14-12-001-30411 (OCS Study: MMS 93-0049).

Mate, B.R., S.L. Nieukirk, and S.D. Kraus. 1997. Satellite-monitored movements of the northern right whale. Journal of Wildlife Management 61(4):1393–1405.

Mate, B. R., B. A. Lagerquist, and J. Calambokidis. 1999. Movements of North Pacific blue whales during their feeding season off southern California and their southern fall migration. Marine Mammal Science 15(4):1246-1257.

Mate, B.R., G.K. Krutzikowsky, and M.H. Winsor. 2000. Satellite-monitored movements of radio-tagged bowhead whales in the Beaufort and Chukchi seas during the late-summer feeding season and fall migration. Canadian Journal of Zoology 78:1168–1181.

Mate, B.R., B.A. Lagerquist, and J. Urban-Ramirez. 2003. A note on using satellite telemetry to document the use of San Ignacio Lagoon by gray whales (Eschrichtius robustus) during their reproductive season. Journal of Cetacean Research and Management 5(2):149-154.

Mate, B.R., P.B. Best, B.A. Lagerquist and M.H. Winsor. 2010. Coastal, offshore, and migratory movements of South African right whales revealed by satellite telemetry. Marine Mammal Science. DOI: 10.1111/j.1748-7692.2010.00412.x

12. Provide a narrative description of the methods and sources that were used in consideration of alternatives to the use of animals and alternatives to painful procedures. An alternative is any procedure that results in a Reduction in the number of animals used, Refinement of techniques (less painful or invasive), or Replacement of animals with non-animal models (the 3 R's).

The minimal narrative should include: the sources and/or databases searched (i.e., index Medicus, Medline, Current Research Information Services, Animal Welfare Information Center), the date of the search, years covered by the search, and the key words and/or search strategy used to determine that no alternatives were available to the painful or distressful procedure. The IACUC Guideline for Literature Searches: http://oregonstate.edu/research/iacuc/iacuc-guideline-literature-searches-alternatives-animal-use

In our considerations of technology refinements to make tags less invasive, we conduct ongoing literature searches using the Aquatic Sciences and Fisheries Abstracts. We limit these search to studies published in the last 10 years. The last search was conducted on November 10, 2016, using keywords "telemetry," satellite-tagging," "radio-tagging," "whales," and "cetaceans." We also receive notification of recent marine mammal publications through MARMAM, a listserv for marine mammal research and conservation discussion. Regular attendance at meetings and conferences particular to our field, such as The Society for Marine Mammalogy conference, Biologging, Ocean Sciences, and the International Whaling Commission's Scientific Committee meeting provide us with information on new technology as well. The community of researchers that engage in remote telemetry studies of whales, however, is very small. We are well aware of other telemetry technologies used by these researchers, including suction-cup and semi-implantable barb systems of tag attachment. These technologies provide short-term tracking

information and are complementary to the longer-term tracking work that we have been successful in. In fact, one of our proposed forms of telemetry, the bioacoustic probe, is attached by means of suction cups. The principal goals of our studies, however, are in providing longer-term tracking or longer-term dive habit information and could not be achieved without our current methods using nearly fully implantable or semi-implantable tags.

Replacement: This research focuses on identifying and characterizing the habitats, dive habits, and feeding/breeding/migratory movements of whales. There are no non-animal alternatives. The whales themselves must be studied. Detailed long-range and long-term movements of whales can be gathered by no other means than remote telemetry techniques.

Reduction: As stated in the sample size discussion above, the number of whales we attempt to tag in a given study is a minimum of what is needed for statistical power. Given the large amount of individual variation we see in whale movements and behavior we are reluctant to reduce our sample sizes any further.

Refinement: We are continually in collaboration with our tag manufacturers to further refine tag technology and reduce tag size. We tested a new tag seven years ago that had a shorter implantable portion, but found they had a significantly shorter retention time than our standard tags, and would not give us the desired results. We continue to use long-dispersant antibiotic coatings on our tags, as well as topical antibiotic ointment on the blades just before deployment. All of our tags are also gas-sterilized prior to our field studies to kill pathogens.

13. Does this proposal duplicate a previous use of animals in teaching or research?

Yes ☐ No ☒ If yes, why is duplication necessary (e.g., new group of students, more rigorous study design, new information, components that were not evaluated previously, etc)?

Rather than duplication of research, our multi-year tagging studies of animals within the same population, or of different populations within the same species, allow us to increase sample sizes to lend power to our results. They allow us to more fully address issues of individual variability in whale movements and behavior, as well as variability due to environmental differences from year to year. Additionally, they will allow us to address the effects of longer-term climate change on whale movements and distribution, or make comparisons between different environmental conditions before and after anthropogenic activities (such as the Deepwater Horizon oil spill).

ANIMAL CARE

14. Animal housing location: List building, floor, room, barn, corral, paddock, or pasture as applicable. Please note that if this is a new housing area, approval from the OSU Attending Veterinarian and IACUC will be needed prior to housing animals.

N/A

15. Indicate the source providing the animals (e.g., Jackson Labs, etc.). If source is a private owner, check Client Consent Form supplement box in Question 22 and complete form.

N/A

16. Who will provide husbandry care for the animals? List unit or person's name.

N/A

17. Who will provide veterinary care for sick or injured animals? If someone other than the OSU Attending Veterinarian will provide this care, please list the individual, their relevant credentials, and their contact information. The OSU Attending Veterinarian has the ultimate responsibility for the veterinary care of all animals used for teaching, research, and testing at Oregon State University. Others may provide veterinary care, with the approval of the University Attending Veterinarian and IACUC. Regardless, the OSU Attending Veterinarian must be listed below and contacted for unexpected animal health-related events.

Unexpected animal health-related events will be reported to the OSU Attending Veterinarian (currently Helen Diggs).

ANIMAL USE

18. Identify all areas where animal procedures will be performed. If procedures will be performed in housing areas, please include these in the list. The information should include: building, room or any other relevant description.

Our tagging/biopsy studies may take place in all oceans, including U.S., foreign, and international waters.

19. Describe in detail all procedures involving the animal(s). This section should include sufficient description of the experimental design or teaching activities, such that it is clear which animals, or groups of animals, will undergo which procedures. Include doses and routes of administration for all agents, medications, chemicals, etc. Describe the order in which procedures will be performed, including the endpoints of the study or animal involvement in the teaching activities. There should be direct correspondence between the descriptions of groups in the "Justification for Use of Live Vertebrates" section, Questions 11 and 12. Do not copy and paste grant information into this section.

We will be applying four types of tags: 1) Argos satellite-monitored location-only tags (hereafter referred to as location-only tags), 2) Argos satellite-monitored lunge-detecting tags (hereafter referred to as lunge-detecting tags), 3) Argos-linked Fastloc GPS/TDR tags (hereafter referred to as Advanced Dive Behavior [ADB] tags), or 4) bioacoustic probes to whales to track their movements and dive habits. The location-only tag and lunge-detecting tags are almost fully implantable while the ADB tag is only partially implantable. The bioacoustic probe is surface mounted with suction-cups, with no implanted portion. Detailed descriptions of the tags are found in the Field Studies Supplement (F), question F7.c. All

four tag types may be used on all species for which authorization is requested. Individual animals may be tagged with a combination of two of the proposed tag types, provided they are not both almost-fully implantable designs (location-only and lunge-detecting tags). The location-only, lunge-detecting, and ADB tags (including the housing, even after the ADB tag has been ejected) will ultimately be shed from the whale, due to hydrodynamic drag and the natural migration of foreign objects out of the tissue. Previously-tagged whales may be tagged again in subsequent field seasons or a tag may be replaced during the same field season if the original tag has fallen off. The latter situation is highly unlikely, however, as very few tags fall off during our short field efforts. We have not placed a restriction on the number of times an individual may be tagged, as we do not believe that tagging poses long-term harm to the animals, and the information gained from longitudinal studies can be of great importance in species that exhibit high degrees of individual variation. For many species, however, with relatively high abundance and extensive range, the likelihood of being able to approach and successfully tag a previously-tagged whale is quite low.

Tagging will take place during approaches in small (usually <8 m) boats (either rigid-hulled inflatables or fiberglass hulls). Approaches to whales will be limited to tagging/biopsy darting, photo-identification and photo-documentation of tag attachment, and behavioral observations. Animals may be approached as closely as 1 m for tagging, with approaches typically no closer than 5 m for biopsy-darting (if biopsy is not obtained during the tagging approach), photography, and observation. Approaches usually occur from behind and to one side of the whale. Whales will not intentionally be approached head on. During tag deployment, the vessel speed will be slightly greater than the whale's speed in order to catch up to the whale and position the tag. We have used this same approach technique successfully since 1990. All satellite tags will be applied using a modified air-powered line-thrower, similar to the ARTS system designed by Heide-Jorgensen et al. (2001). A buoyant deployment shaft fits into the applicator barrel and holds the tag. The shaft separates from the tag after attachment and is usually recovered. The bioacoustic probe is typically applied with a 9 m telescoping pole. Tags will be placed on the dorsal surface of the animals, up to approximately 5 m in front of the dorsal fin/ridge/hump, or at least 2 m behind the blowhole in the case of right and bowhead whales.

Skin and blubber samples may be taken as biopsies or sloughed skin from each tagged whale, for sex and reproductive condition determination, and genetic analysis. Previously-tagged whales may be biopsy-sampled in subsequent encounters (subsequent field seasons) for post-tag monitoring (genetic identification and health assessment). We have not placed a limit on the number of times an animal is biopsy sampled. Realistically, the chances of biopsy sampling a previously-tagged whale are quite low. This is due to the fact that we can rarely identify an individual whale in the field in real time (most re-identifications result from careful comparison of whale photographs in the lab), and we are not permitted to biopsy sample untagged whales. So unless the whale has a tag still attached, or is positively identified as being tagged previously, we will not collect a biopsy sample.

Biopsy samples will be collected through the deployment of a biopsy dart from a 150 lb crossbow or a rifle. Ideally, the biopsy will be obtained during the same surfacing as the tag deployment. If we are unsuccessful in obtaining a biopsy sample during tag deployment, the tagged whale may be approached again to obtain a biopsy. The biopsy consists of a small plug of tissue (6 mm x 40 mm) removed from the whale's back using a dart with a sterilized coring tip. The dart is free-floating and is retrieved immediately

after sampling. Additional samples of sloughed skin may be collected from the water with a dip net when single whales are approached and tagged. However, such samples are often not always useful, as the DNA in sloughed skin has deteriorated. A small portion of a skin sample will be preserved in an RNA enrichment reagent (RNALater). The remainder of the skin is preserved in ethanol and the rest of the sample (primarily blubber) is frozen. All samples will be labeled with the date and location of collection, tag number, species name, age class, and sex, if known. At the conclusion of each field season, samples will be sent for analysis to laboratories (such as OSU Marine Mammal Institute's Cetacean Conservation Genetics Laboratory, under the direction of Scott Baker) specializing in genetic techniques appropriate for each species. Sometimes samples will be shared with collaborators who have other institutional needs.

Still photographs and video footage will be taken for individual whale identification and for documentation of tag deployment and attachment. Digital SLR cameras with telephoto lenses (up to 300 mm) will be used for still photography. Digital video cameras with high shutter speed capability (>1/1000 of a second) will be used for video documentation. All images will be labeled with the date and location of collection, tag number, species name, age class and sex, and stored on computers as well as external hard drives. Identification photographs will be shared with collaborators maintaining identification catalogues for those species.

Larger boats may be used for follow-up photography and observation. Aerial survey flights may be required at times when it is difficult to locate whales by boat. Flights will typically be flown at 300 m using either single or twin-engine light aircraft. The aircraft may fly as low as 150 m at times to determine whether a whale has a tag. Towed acoustic arrays and hand-held directional hydrophones may also be used occasionally in the passive detection of whales. Prey species and abundance may be assessed with the use of sonar systems, towed nets or optical plankton counters.

Literature Cited

Heide- Jørgensen, M. P., L. Kleivane, N. Oeien, K. L. Laidre and M. V. Jensen. 2001. A new technique for deploying satellite transmitters on baleen whales: Tracking a blue whale (Balaenoptera musculus) in the North Atlantic. Marine Mammal Science 17(4): 949-954.

20. Describe method(s) of euthanasia and carcass disposal or other disposition, if applicable. Methods of euthanasia employed should be acceptable, according to the American Veterinary Medical Association (AVMA) "Guidelines on Euthanasia". If a method is considered conditionally acceptable or unacceptable, scientific justification is required. Methods utilized to ensure euthanasia (i.e., secondary means) also should be included in this description.

N/A

21. Describe potential adverse consequences that may occur to the animal. These can include expected sources of discomfort, distress, or pain from the procedures performed, loss of life (death), adverse phenotypes from transgenic strains, surgical complications, etc.

We expect no significant adverse consequences to the animals in this research. Over 100 of our tagged whales have been sighted to date (out of 752 whales satellite-tagged between 1986 and 2016), either through opportunistic observations or planned follow-up studies, over periods of up to 19 years

after tagging. In no case did the animals appear to be in poor health. None of the animals were emaciated or had higher than normal external parasite loads. Tagged whales did not behave differently than untagged whales. Resighting rates of tagged versus untagged North Atlantic and southern right whales are identical (M. Fujiwara pers. comm., Best and Mate, 2007). Best and Mate (2007) have recently shown that the reproductive rates of tagged southern right whales are similar to that of untagged whales, and unchanged from their pre-tagging reproductive history. This finding still holds, with the addition of four more years of resight information for southern right whales (Best et al. 2014). In an examination of the sighting histories of 29 of our tagged gray whales and 85 of our tagged blue whales, Calambokidis et al. (2016) showed no evidence of a survival effect between tagged and untagged blue whales, and a small, but not statistically significant reduction in survival of tagged versus untagged gray whales. The gray whale result was primarily driven by the lack of resighting during the study period of two tagged gray whales and the death of a third gray whale from undetermined causes.

The condition of tag sites varied between animals. Tissue extrusion (white, pale yellow, or beige) was seen around the tag for 5 of 31 resighted blue whales (2-120 days after tagging), 2 of 24 resighted sperm whales (17 and 281 days after tagging), and 1 of 31 resighted gray whales (12 days after tagging).

In some cases, swelling has been seen around the tag sites, either localized (extending 3-15 cm around the tag) or regional (30-60 cm around the tag), but most of these that have been resighted (right whales, sperm whales, gray whales, and blue whales) have shown considerable improvement or complete healing. In any event, these circumstances are not viewed as life threatening (J. Geraci, pers. comm. from Right Whale Tagging Workshop), and in most cases appears to be short-term. Four of nine resighted North Atlantic right whales had swelling (two localized and two regional) around their tag sites (Mate et al. 2007). After one year, only one of these animals still had swelling. Five of 39 resighted sperm whales had swelling (four localized and two regional) around their tag sites. The two regional swellings were observed 281 and 289 days after tagging. The localized swellings around the tag sites were observed from 213-350 days after tagging. Six of 31 resighted blue whales had swelling (3 localized and 3 regional) around the tag sites, ranging from 1-7 days post-tagging, and one blue whale resighted 319 days after tagging had slight localized swelling around the tag site with the tag (or portion of) still attached. One of 15 resighted southern right whales had slight localized swelling around the tag site one year after tagging. Two of the 31 resighted gray whales had localized swelling while the tags were still attached, but this swelling decreased after the tags were lost. Veterinary opinion is mixed about whether swelling is due to infection or a foreign body response (with the latter explanation prevailing). In all of the resighting cases mentioned, the whales appeared to be in good health (not noticeably underweight) and behaved "normally" according to observers' reports. One recent study, however, suggested that swelling associated with long-term retention of attachment material from an earlier-style tag may have resulted in an apparently reduced reproductive rate in the case of a blue whale (Gendron et al. 2015). Following the extrusion of the attachment material, the swelling disappeared and the whale was subsequently resighted with a new calf.

Whales observed after tag loss have shown little or no evidence of scarring: gray whales - up to 19 years after tagging; North Atlantic right whales - from 16 days to 2 years after tag loss; southern right whales – up to 11 years after tagging; humpback whales - ranging from 4-35 days after tag loss; sperm whales 3-14 months after tagging. In all cases where scars have existed, they consisted of lightened or fully

repigmented divots (with sizes ranging up to 1-2 cm deep by 4-30 cm diameter). Additionally, in some gray whale cases, there was also skin sloughage and cyamid (whale lice) growth at the tag sites.

We cannot know what happens to whales we never see again. Given the identical resighting rates for tagged versus untagged North Atlantic and southern right whales, the identical reproductive rate of tagged versus untagged southern right whales (as well as for pre- and post-tagging), the apparent good health of animals we do resight, and the behavior of tracked whales we do not resight (extensive movements, realistic travel speeds), we maintain our belief that tagging is not a significant detriment to animal health (Mate et al. 2007). Continued attachment of tags (up to two years for North Atlantic right whales, 20 months for sperm whales, 16 months for blue whales, and 11 years for one southern right whale) may be the best indicator of tags having minimal effect (S. Ridgeway, pers. comm.), as physiological and behavioral characteristics would result in tag loss if tags were a major irritant. Additionally, when we resight tagged whales we often find them in the presence of untagged whales, suggesting that the movements and habitat choices of tagged whales are also representative of the untagged whales.

Literature Cited

Best, P.B. and B.R. Mate. 2007. Sighting history and observations of southern right whales following satellite tagging off South Africa. Journal of Cetacean Research and Management 9(2): 111-114.

Best P.B., B. Mate, and B.A. Lagerquist. 2014. Tag retention, wound healing, and subsequent reproductive history of southern right whales following satellite-tagging. Marine Mammal Science. 31(2):520-539.

Calambokidis, J., A. Zerbini, K. Flynn, A. Douglas, S. Norman, B. Mate, C. Hayslip, D. Gendron. R. Sears, J. Jacobsen, and D. Goley. 2015. Quantitative examination of long-term impact of implant tagging on survival of gray and blue whales. Oral Presentation at Society for Marine Mammalogy Biennial Conference. San Francisco, December 2015.

Gendron D, I. Martinez Serrano, A. Ugalde de la Cruz, J. Calambokidis, and B. Mate. 2015. Long-term individual sighting history database: an effective tool to monitor satellite tag effects on cetaceans. Endangered Species Research. 26(3):235-241.

Mate, B., R. Mesecar and B. Lagerquist. 2007. The evolution of satellite-monitored radio tags for large whales: one laboratory's experience. Deep Sea Research Part II: Topical Studies in Oceanography 54:224-247.

21A. Describe any actions that will be taken to prevent or minimize adverse consequences.

To reduce the risk of infection, all tags are partially coated with a broad-spectrum antibiotic (Gentamycin Sulfate) mixed with a long-dispersant methacrylate. This allows for a continual release of antibiotic into the tag site for a period of up to 5 months. Following tag construction all tags are placed in

gas permeable bags and gas sterilized. They are not removed from these bags until immediately prior to deployment. Bladed attachments are then coated with antibiotic ointment just before deployment.

22. Check any of the following that apply. Complete and submit all applicable supplements.

- ☐ Antibody production (Antibody Production Supplement)
- ☐ Breeding colony or sentinel animals (Breeding Colony & Surveillance Supplement)
- ☐ Death of the animals as an indicator or data point in the research or instruction (Death as an End Point Supplement)
- ☒ Field studies (Field Studies Supplement)
- ☐ Surgery (Surgery Supplement)
- ☐ Herd animals including poultry or stocks of fish (Herd/Flock Supplement)
- ☐ Category "E", unrelieved discomfort, distress, or pain (Category "E" Supplement)
- ☐ Client Consent Form for privately owned animals (CCF Supplement)

23. Other agents used in the research - check appropriate boxes and complete the Research Agent Use in Animals Form that can be found at: http://oregonstate.edu/ehs/forms/auf.doc. It is the responsibility of the PI to secure any other compliance committee approvals necessary. Questions regarding approval process for other safety committees (Institutional Biosafety Committee (IBC), Radiation Safety Committee (RSC), and Chemical Safety Committee (CSC)) should be directed to the appropriate committee. The IACUC Office can provide this contact information.

- ☐ Radioactive isotopes administered to the animal
- ☐ Infectious agents administered to the animal
- ☐ Carcinogens administered to the animal
- ☐ Recombinant DNA products administered to the animal
- ☐ Breeding or creation of genetically modified animals

24. Will the project involve participants diving and/or boating? Yes ☒ No ☐
If yes, approval is needed from the Diving Board and/or Boating Safety Officer.

PARTICIPANTS (P) SUPPLEMENT

List the PI and all staff that will perform work described in this application.

For class activities, include instructional staff . All Participants must complete Animal Welfare Education Training, the Animal Handler Safety Awareness Training, and enroll in the Animal Exposure Occupational Health and Safety Program. Complete instructions are available here.

The PI responsible for this project should be the first person listed.

In the event that an emergency issue arises, it is important that the University Veterinary staff or IACUC be able to contact an individual who can make decisions for animals described in this proposal. Please list subsequent individuals in preferred contact order.

Add additional personnel boxes, or pages, as needed.

Name:	Bruce R Mate		Department:	CAS/Marine Mammal Institute	
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365				
Work Email:	bruce.mate@oregonstate.edu		Work Phone:	541-867-0202	
Participant's ACUP Role:	PI				
Experience & Qualifications *specific to this ACUP*:	Dr. Mate, Director of OSU's Marine Mammal Institute (MMI), has been working in the marine mammal field for 47 years and is highly qualified to accomplish the objectives in this application. He was the first person to deploy a satellite-monitored radio tag on a large whale, in 1986, and has successfully tagged and tracked eight species of large whales throughout the world since then, for a total of over 750 animals.				
Animal Welfare Education completed?	Yes ☒	Pending ☐	Animal Exposure/OHS Enrollment completed?	Yes ☒	Pending ☐
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

Name:	Tomas Follett		Department:	CAS/Marine Mammal Institute	
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365				
Work Email:	tomas.follett@oregonstate.edu		Work Phone:	541-867-0164	
Participant's ACUP Role:	Research Assistant				
Experience & Qualifications *specific to this ACUP*:	Tomas Follett has worked with the Marine Mammal Institute for 19 years and has participated in MMI satellite tagging studies with humpback, blue, fin, gray, and sperm whales. His roles in the field have included boat driver, biopsy sampler, photographer, and field note recorder.				
Animal Welfare Education completed?	Yes ☒	Pending ☐	Animal Exposure/OHS Enrollment completed?	Yes ☒	Pending ☐
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

Name:	Craig Hayslip	Department:	CAS/Marine Mammal Institute	
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365			
Work Email:	craig.hayslip@oregonstate.edu	Work Phone:	541-867-0150	
Participant's ACUP Role:	Research Assistant			
Experience & Qualifications *specific to this ACUP*:	Craig Hayslip has worked with the Marine Mammal Institute for 11 years, participating in satellite tagging studies of humpback, blue, fin, sperm, and gray whales in that time. Craig has been onboard the tagging boat in all of those studies, becoming extremely well acquainted with our tagging procedures. He has been up on the tagging platform, collecting biopsy samples of gray and humpback whales. This put him directly behind the person deploying tags and required shooting a dart from a crossbow into a whale's back, a procedure very similar to tagging. We plan to train Craig further to become an alternate tagger. Craig's other roles in the field have included photographer and boat driver.			

Animal Welfare Education completed?	Yes ☒	Pending ☐	Animal Exposure/OHS Enrollment completed?	Yes ☒	Pending ☐
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

Name:	Ladd Irvine	Department:	CAS/Marine Mammal Institute
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365		
Work Email:	ladd.irvine@oregonstate.edu	Work Phone:	541-867-0394
Participant's ACUP Role:	Research Assistant		
Experience & Qualifications *specific to this ACUP*:	Ladd Irvine has worked with the Marine Mammal Institute for 17 years and has extensive satellite tagging experience with humpback, blue, fin, sperm, and gray whales. Ladd is the MMIs primary tagger, but he has also fulfilled the role of boat driver and biopsy sampler in the field.		

Animal Welfare Education completed?	Yes ☒	Pending ☐	Animal Exposure/OHS Enrollment completed?	Yes ☒	Pending ☐
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

Name:	Barbara Lagerquist	Department:	CAS/Marine Mammal Institute
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365		
Work Email:	barb.lagerquist@oregonstate.edu	Work Phone:	541-867-0322
Participant's ACUP Role:	Research Assistant		

Experience & Qualifications *specific to this ACUP*:	Barbara Lagerquist has worked with the Marine Mammal Institute for 24 years, studying blue, fin, humpback, gray, North Atlantic right, southern right, and sperm whales in that time. Her research experience includes satellite tagging as well as shore-based visual observation studies. Prior to coming to the MMI, Barbara studied humpback whales in Hawaii and Australia, with experience in shore-based Theodolite tracking, aerial surveys, and photographic identification studies. Barb's roles in the field have included boat driver, biopsy sampler, photographer and field note taker. She has been up on the tagging platform, collecting biopsy samples of blue and fin whales. This put her directly behind the person deploying tags and required shooting a dart from a crossbow into a whale's back, a procedure very similar to tagging. We plan to train Barb further to become an alternate tagger.				
Animal Welfare Education completed?	Yes ☒	Pending ☐	Animal Exposure/OHS Enrollment completed?	Yes ☒	Pending ☐
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

Name:	Daniel Palacios		Department:	CAS/Marine Mammal Institute	
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365				
Work Email:	daniel.palacios@oregonstate.edu		Work Phone:	541-867-0162	
Participant's ACUP Role:	Assistant Professor (Senior Research)				
Experience & Qualifications *specific to this ACUP*:	Daniel Palacios got his PhD in 2003 with Bruce Mate at the Marine Mammal Institute, studying cetacean abundance and habitat characteristics in the Eastern Tropical Pacific. While at OSU, he participated in MMI satellite tagging studies with humpback and sperm whales. Daniel accepted a position as Assistant Professor with the Marine Mammal Institute in 2013 and has participated in MMI satellite tagging studies of blue, fin, and humpback whales since then. Daniel has been trained by Ladd Irvine to tag whales, and has also served as biopsy sampler in the field.				
Animal Welfare Education completed?	Yes ☒	Pending ☐		Yes ☒	Pending ☐

			Animal Exposure/OHS Enrollment completed?		
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

Name:	Ken Serven		Department:	CAS/Marine Mammal Institute	
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365				
Work Email:	ken.serven@oregonstate.edu		Work Phone:	541-867-0202	
Participant's ACUP Role:	Research Assistant				
Experience & Qualifications *specific to this ACUP*:	Ken Serven has worked with the Marine Mammal Institute for 7 years and has participated in MMI satellite tagging studies with blue, fin, gray, and sperm whales. Ken's role in the field includes boat driver, biopsy sampler, and field note recorder.				
Animal Welfare Education completed?	Yes ☒	Pending ☐	Animal Exposure/OHS Enrollment completed?	Yes ☒	Pending ☐
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

Name:	Martha Winsor	Department:	CAS/Marine Mammal Institute
Work Address:	2030 SE Marine Science Drive, Newport, OR 97365		
Work Email:	martha.winsor@oregonstate.edu	Work Phone:	541-867-0150
Participant's ACUP Role:	Research Assistant		

Experience & Qualifications *specific to this ACUP*:	Martha Winsor has worked with the Marine Mammal Institute for 21 years and has participated in MMI satellite tagging studies with humpback, blue, fin, and sperm whales. Martha's role in the field includes biopsy sampler, photographer, and field note recorder.				
Animal Welfare Education completed?	Yes ☒	Pending ☐	Animal Exposure/OHS Enrollment completed?	Yes ☒	Pending ☐
Animal Handler Safety Training completed?	Yes ☒	Pending ☐			
Has/will participant receive procedure-specific training?	Yes ☒	Pending ☐	Are personnel training records maintained? Sample Records found here.	Yes ☒	Pending ☐

FIELD STUDIES (F) SUPPLEMENT
(FILL OUT ONLY IF APPLICABLE)

F1. Are the animal species to be used listed as endangered or threatened? Yes ☒ No ☐

F2. Are permits required? Yes ☒ No ☐

If yes, list the necessary permits and confirm that all necessary permits have, or will be obtained prior to initiation of animal work. If none are required, please explain why.

This work requires a Marine Mammal Protection Act/Endangered Species Act Scientific Research Permit. We currently hold NMFS permit # 14856 for tagging studies, which will expire on December 31, 2018. An application for a new permit will be filed with the National Marine Fisheries Service in June 2017 to allow 1.5 years for both internal and external review and completion of Biological Opinion.

F3. Field Study Location(s): Field work may take place in the Pacific, Atlantic, Arctic, and Indian oceans, as well as the Gulf of Mexico and the Mediterranean, Bering, Chukchi, and Beaufort Seas.

F4. Will animals be captured alive? Yes ☐ No ☒

a. Method of capture and frequency of trap checks?

b. If released, where will captured animals be released?

c. If not released, what will happen to the animals?

d. What precautions will be taken to prevent capture of non-target species?

e. What is the expected injury or death rate during capture?

f. What precautions will be used to minimize distress, injury or death during capture?

F5. In the event of injury or illness necessitating euthanasia or for non-survival capture, what method of euthanasia will be used? List agent, dose, and route.

N/A

F6. Does this study involve predator and prey interaction? Yes ☐ No ☒

If yes, what consideration was given to use of non-live animal prey?

F7. Will a telemetry unit be implanted or attached? Yes ☒ No ☐

a. If yes, who will do the implantation (please complete the "Surgery (S)" supplement)?
Bruce Mate, Ladd Irvine, Daniel Palacios, Craig Hayslip, and Barbara Lagerquist will be deploying tags.

b. What are their qualifications and experience with performing the procedure?
Dr. Mate pioneered the use of this procedure for whales and has been deploying satellite-monitored radio tags since 1986. He personally trained Ladd Irvine, after multiple field seasons together. Ladd Irvine has now been deploying tags since 2005. Ladd Irvine trained Daniel Palacios, and will train Craig Hayslip and Barbara Lagerquist.

c. Describe dimensions and weight of the unit; anatomical site and method of attachment to the animal; procedure for removal at the conclusion of the study or probable consequences to the animal if not removed.

Research objectives will be met through the deployment of location-only tags, lunge-detecting tags, ADB tags, or bioacoustic probes. The location-only and lunge-detecting tags are almost fully implantable while the ADB tag is only partially implantable. The bioacoustic probe is surface mounted with suction-cups, with no implanted portion.

The location-only and lunge-detecting tags are composed of a main body, a penetrating tip, and an anchoring system. The main body consists of a certified Argos transmitter (either from Wildlife Computers or Telonics), housed in either an air-filled or epoxy-filled stainless steel cylinder

(approximately 2.1 cm in diameter by <23 cm in length, depending upon the version). A flexible whip antenna and a saltwater conductivity switch are mounted on the distal endcap of this cylinder, while a penetrating tip is screwed onto the other end. The antenna/switch endcap has two perpendicular stops, approximately 0.6 cm in diameter and extending approximately 1.5 cm laterally to prevent tags from embedding too deeply on deployment or migrating inward after deployment. The penetrating tip consists of a Delrin® nose cone, into which is pressed a ferrule shaft with four double-edged blades. The anchoring system consists of metal wires mounted behind the blades on the penetrating tip and two rows of outwardly curved metal strips mounted on the main body at the nose cone (proximal) end. Total tag weight varies by size and type, but is typically <220 grams (g). Tags are partially coated with a broad-spectrum antibiotic (Gentamycin Sulfate) mixed with a long-dispersant methacrylate. This allows for a continual release of antibiotic into the tag site for a period of up to 5 months.

In addition to providing transmissions for location calculation, the location-only tag can report a modest amount of data, such as the cumulative number of surfacings an animal makes, the percentage of time at the surface, and the percentage of time in user-specified temperature ranges. The lunge-detecting tag is equipped with a pressure transducer and a 3-axis accelerometer, and provides information on dive duration, depth, and the number of lunges detected during a dive. Tags are programmed to transmit only when out of the water and life expectancy of the electronics is adjustable depending on the transmission duty cycle. With our typical baleen whale duty cycle, electronic life expectancy of location-only tags is 12 months. We program our sperm whale tags to last 24 months. Lunge-detecting tags have increased energy demands over location-only tags due to on-board processing of accelerometer data, and therefore have a lower electronic life expectancy. They are programmed to last approximately 100 days. Tags are ultimately shed from the animals due to hydrodynamic drag and the natural migration of foreign objects out of the tissue. The timing of this shedding will vary depending on the species. Based on past deployments, attachment durations are longest for sperm whales, averaging 185 days with a maximum of 607 days. Attachment durations are shortest for humpback whales, with an average of 39 days and a maximum of 220 days.

The ADB tag consists of a certified Argos transmitter and a Wildlife Computers Time-Depth Recorder, with a three-axis accelerometer and magnetometer, cast in an epoxy tube (2.0 cm in diameter and 11.5 cm long). A FastLoc® geographic positioning system (GPS) receiver, encased in syntactic foam (10.0-cm diameter dome with a maximum height of 4.0 cm), is attached to one end of the epoxy tube. Three light-emitting diode (LED) lights are mounted on top of the syntactic foam to facilitate relocation of the tag. The tubular portion of the tag is slid into a cylindrical stainless steel tag housing (2.6 cm in diameter and 14.5 cm long) for deployment. A circular stainless steel plate, or collar, is welded onto the distal end of the housing to protect the syntactic foam during deployment. A penetrating tip and anchoring system, similar to that of the location-only and lunge-detecting tags, is mounted onto the cylindrical end of the tag housing. The cylindrical portion of the tag housing is designed for implantation beneath the whale's skin while the plate and syntactic foam GPS receiver sit atop the whale's back. The ADB tag and housing weigh approximately 470 g (approximately 240 g for the tag and approximately 230 g for the housing). A plastic "D-ring" is mounted on the bottom of the syntactic foam with a corrodible wire. This "D-ring" passes through a slot in the stainless steel plate and is secured on the backside of the plate with a screw. After a pre-determined time (typically 3-6 weeks), an electrical current is activated within the tag,

oxidizing the corrodible wire, whereupon the tag is ejected from the housing and floats to the surface for recovery.

The ADB tags are programmed to collect a GPS-quality FastLoc® location every 7 minutes (min) or as soon thereafter as the whale surfaces from a dive. Dive depth is recorded every 1 second (s) with 2-m vertical resolution. Body orientation (from the accelerometer) and magnetic compass heading (from the magnetometer) are also recorded at 1-s intervals. These data are all archived onboard the tag and accessible only when the tag is recovered. Qualifying dives (those greater than 2 min in duration and 10 m in depth) are also summarized for transmission through the Argos system along with GPS locations recorded by the tag. Three dive summary histograms are created for qualifying dives every 6 h during tag operation. The histograms summarize the percentage of time spent at different depths (%TADHist), the maximum dive depths (MaxDiveDeptHist), and maximum dive durations (DiveDurHist). Separate summary messages (behavior messages) describing individual qualifying dives are also generated by recording dive duration, maximum dive depth, dive shape (U-, V-, or square-shaped- and whether the U- or V-shaped dives are skewed right, left or centered) and the subsequent surfacing duration. Up to four consecutive summarized dives are transmitted in each behavior message. A single Argos message from the tag can send either one GPS location, one histogram summary, or one behavior message (summarizing four dives).

Anticipated life expectancy of the ADB tag is adjustable depending on the duty cycle, but will not nearly approach the longevity of the location-only or lunge-detecting tags given the increased energy demands of GPS acquisition, and increased hydrodynamic drag on the un-implanted portion. With continuous running we will know the precise location of every surfacing, but we expect the electronic longevity to be approximately 4-8 weeks. The tag housing will also ultimately be shed from the animal after a shorter period of time than for location-only or lunge-detecting tags because of the additional drag on the circular plate portion.

Future development of the ADB tag will include the addition of a thumb-sized acoustic dosimeter which will measure received sound levels in five 5-dB ranges, each of which can be defined with different frequency bands and duration criteria. The frequency bands and duration criteria will be chosen so as to allow reception of both anthropogenic and whale-generated sounds. Acoustic dosimeter data will be archived for downloading after tag recovery. The addition of a dosimeter will add approximately 2.6 cm of height to the syntactic foam dome and approximately 50 g to the total weight of the GPS tag.

The bioacoustic probe is a tag developed by Bill Burgess of Greeneridege Sciences, Inc. It will be coupled to a VHF transmitter, syntactic foam float, and two rubber suction cups for attachment to a whale. The bioacoustic probe is made up of a hydrophone, pressure transducer, temperature sensor, light meter and accelerometer encapsulated in polyurethane, measuring 19.5 cm in length by 3.0 cm in diameter, and weighing 200 g. In addition to recording ambient sound, this tag is capable of sampling dive depth, ambient temperature, light level, swim velocity and angle at pre-programmed times throughout a dive. This tag is designed for short-term deployments (<8 h) as it has to be recovered to retrieve the data. The VHF transmitter is incorporated into the tag for relocation of the whale and tag recovery after its release. Computer programs provided by Greeneridge Sciences, Inc. will be used to retrieve and interrogate the data.

Some of our previously deployed Time-Depth-Recording tags (TDR's) have incorporated a Vemco model V22P acoustic transmitter in the tag to allow tracking while a whale was submerged. The acoustic transmitter emitted 36 kHz pulses at 165 dB (re 1 μPa at 1 m) at intervals proportional to the depth of the tag (e.g. every 1.03 s at 10 m and 0.76 s at 200 m). Such transmitters (or models with similar acoustic characteristics) may be included in the bioacoustic probe to aid in relocation and recovery of the tag.

All four tag types (location-only, lunge-detecting, ADB, and bioacoustic probe) may be used on all species for which authorization is requested. Future location-only, lunge-detecting, and ADB tags may vary slightly in terms of materials, but will not exceed the size/weight of current tags. Animals may be tagged with a combination of two of the proposed tag types, provided they are not both almost-fully implantable designs (location-only and lunge-detecting tags). Deploying two tags on the same whale would offer complementary results. Our almost fully implantable location-only tags yield long term tracking information, with only rudimentary dive information, whereas the partially-implantable ADB tag yields shorter-term (4-8 weeks) tracking with very detailed dive information and acoustic recordings. The same complementary results would be true for a location-only/bioacoustic probe combination, but with a shorter period of time for the bioacoustic results. In terms of ground-truthing the detailed dive information, deploying both an ADB tag and a bioacoustic probe on the same animal would be provide very valuable information. Similarly, the combination of both a lunge-detecting tag and an ADB tag on the same animal would allow for confirmation of the lunge-detecting tag's ability to accurately measure foraging behavior without the need for tag recovery.

Tags will be placed on the dorsal surface of the animals, up to approximately 5 m in front of the dorsal fin/ridge/hump, or at least 2 m behind the blowhole in the case of right and bowhead whales. Satellite tags are placed as close as possible to (but not directly on) the midline of the whale's back, to ensure best transmission reception by the satellites. All satellite tags will be applied using a modified air-powered line-thrower. A buoyant deployment shaft fits into the applicator barrel and holds the tag. The shaft separates from the tag after attachment and is usually recovered. The bioacoustic probe is typically applied with a 9 m telescoping pole.

SURGERY SUPPLEMENT (S)
(FILL OUT ONLY IF APPLICABLE; ONE SUPPLEMENT FOR EACH SURGERY TYPE)

S1. Will this be a survival or non-survival (terminal) procedure? Tagging and biopsy darting are survival procedures.

Please list the type (name) of the surgical procedure(s).

N/A

S1a. If this is a survival surgery, is this a minor or major procedure? A major surgery is defined as one that penetrates or exposes a body cavity or produces substantial impairment of physical or physiological function.

Tagging and biopsy darting are minor procedures, not involving penetration of body cavities or substantial impairment.

S2. If the surgery involves recovery from general anesthesia (survival), will more than one survival surgery be performed on the same animal during its lifetime?

Yes ☐ No ☒

If yes, what is the time frame between surgeries and the scientific justification for multiple survival surgeries on the same animal?

S3. Where will the procedure be performed? List the building, floor and room number or field site, as appropriate.

Procedures are performed on the ocean.

S4. Describe pre-operative preparation of the animal, including; preparation of the surgical location, and surgeon. Include any anesthetic and analgesic agents (list name(s), dose(s) and route(s) of administration).

Perioperative preparations: N/A

Anesthetic, analgesic agents & administration: N/A

S5. Describe in detail the surgical procedures.

Our procedures involve the remote deployment of satellite-monitored radio tags on whales and the collection of a sample of skin and blubber through biopsy darting. In the former case, an air-powered rifle is used to deliver the tag into the whale's back. In the latter case, a 150-lb crossbow is used to launch a dart with a coring tip to extract a small (6 mm x 40 mm) plug of blubber and skin from a whale's back. Both procedures occur from a small boat.

S5a. Who will perform the surgery? List that person's name, training and/or experience (recent or other) with the surgical procedure.

Bruce Mate, Ladd Irvine, Daniel Palacios, Craig Hayslip, and Barbara Lagerquist will be deploying the tags. Bruce Mate pioneered the use of this procedure for whales and has been deploying satellite-monitored radio tags since 1986. He personally trained Ladd Irvine, who has been deploying tags since 2005. Craig Hayslip has been a part of our tagging team on all of our field studies since 2005, and is now being trained to deploy tags by Ladd Irvine. Barbara Lagerquist has been a part of our tagging team since 1993 and will also be trained to deploy tags by Ladd Irvine.

S6. Describe sterile techniques that will be used during the survival procedures or provide a copy of a current standard operating procedure (SOP).

All tags are partially coated with a broad-spectrum antibiotic (Gentamycin Sulfate) mixed with a long-dispersant methacrylate. This allows for a continual release of antibiotic into the tag site for a period of up to 5 months. Following tag construction all tags are placed in gas permeable bags and gas sterilized. They are not removed from these bags until immediately prior to deployment. Bladed attachments are then coated with antibiotic ointment just before deployment.

S7. Describe postoperative care procedures and practices (e.g., pain management, wound and infection control, diet augmentation, physical therapy, monitoring frequency, etc.) or provide a copy of a current SOP. Include the name of medications, doses, route, and frequency of administration.

Post-operative procedures: N/A

Post-operative medication agents & administration: N/A